Exposure Reconstruction: Evaluating Personal Injury Claims

Jim Rasmuson, PhD, CIH, DABT
Chemistry & Industrial Hygiene, Inc.
(303)420-8242 or Jim@C-IH.com

Evaluating Personal Injury Claims

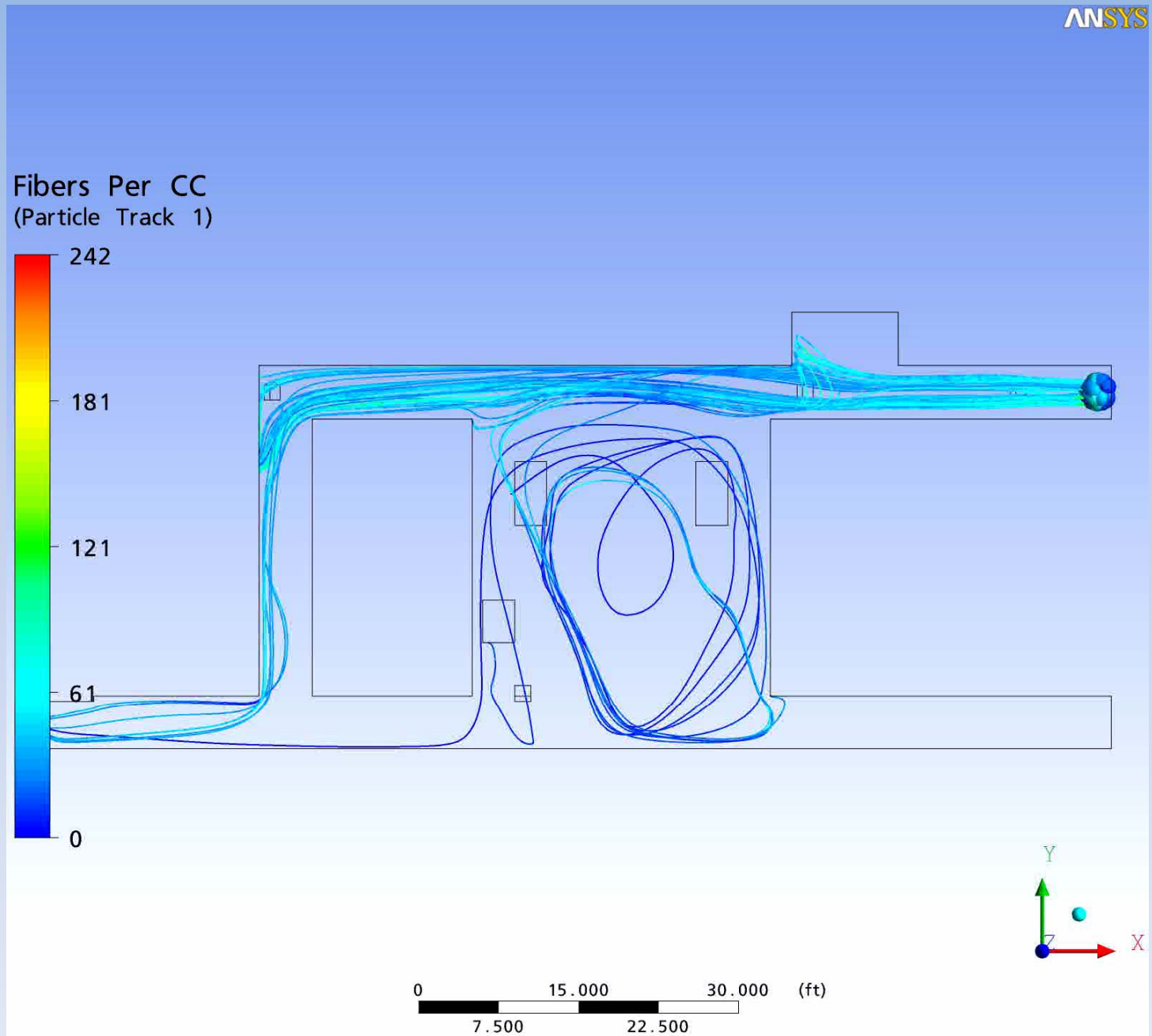
Try not to wear a plaintiff's or a defendant's hat: be objective

- Would my opinion be the same if I worked for the "other side" in the matter?
- If involved in medical diagnosis, take a fresh look at the matter (avoid the echo effect)
- Misdiagnosis or misinformation, even under the excuse of being generous to the plaintiff or giving the benefit of the doubt, can cause emotional or physical harm to the claimant or his family

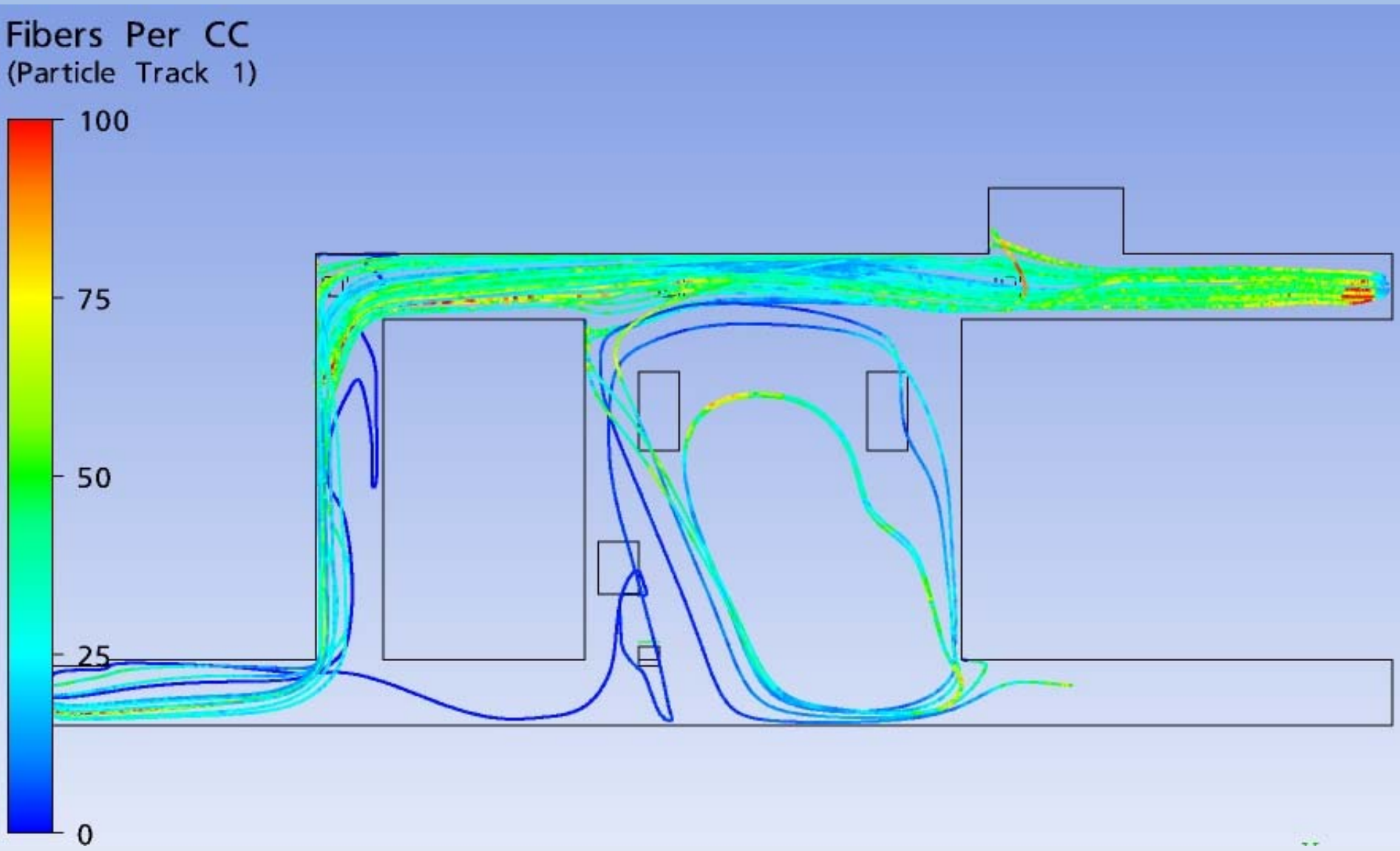
Use standardized and well accepted methodology

- Work in the areas of consensus whenever possible
- Look for methodologies and positions endorsed or published by professional societies
- Discuss your evaluation with colleagues – don’t be the “Lone Ranger”

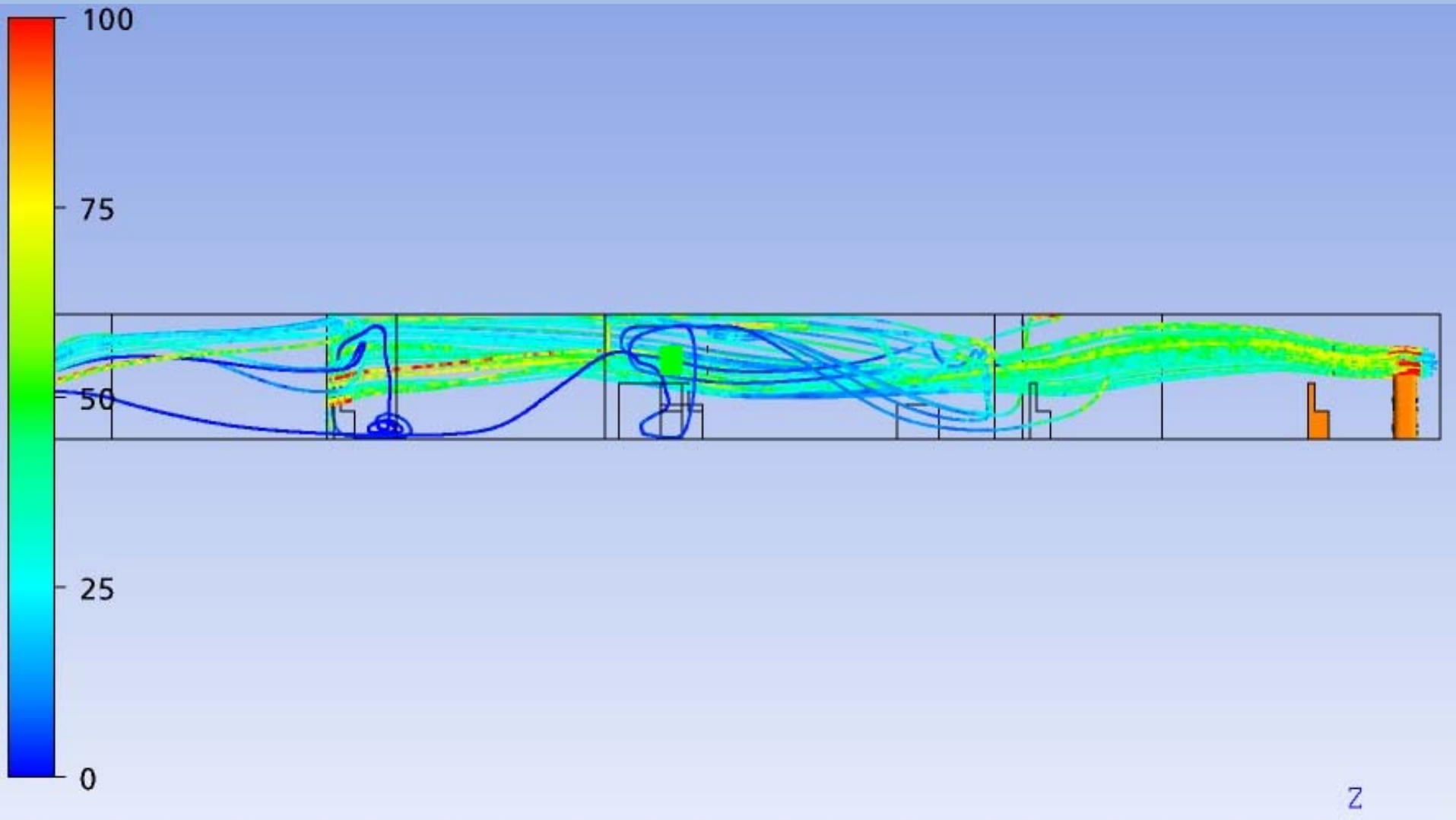
Steady State Fate and Transport of Respirable Asbestos Fibers in Office Space



Steady-State Particle Tracks – Nighttime Conditions, BZ Height



Steady-State Particle Tracks – Nighttime Conditions, Elevation View



Report concisely and transparently

- Document the bases of your assessment
- Don’t be afraid to identify areas of uncertainty
- Don’t try to oversell your opinion

Be a good listener

- Avoid argumentative or defensive behavior in presenting your evaluation
  - Let your “yes” be yes and your “no”be no
- Learn from detractors, adversaries, and alternative points of view
  - Make adjustments, as appropriate
- Respond, rather than react to criticism and challenges

Exposure Reconstruction

Exposure Reconstruction

- **Use methodology:**
  - **Standardized and generally recognized**
  - **Endorsed by a professional organization**
  - **Accepted by court or hearing body in applicable jurisdiction**

"Exposure monitoring is not essential to exposure assessment. Many occupational exposures can be assessed without monitoring data."

-- J. Damiano and J.R. Mulhausen, *A Strategy for Assessing and Managing Occupational Exposures,* (AIHA) 1998.

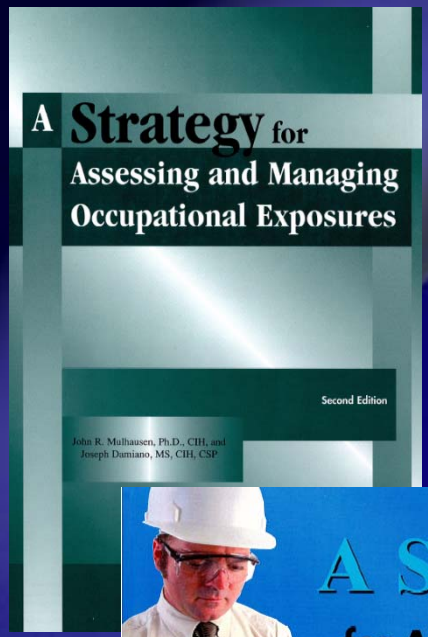
Do you agree or disagree with this statement? Let's discuss.

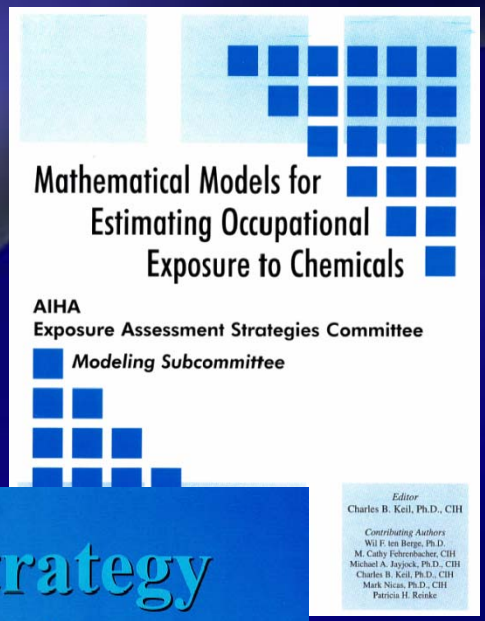
Exposure Assessment

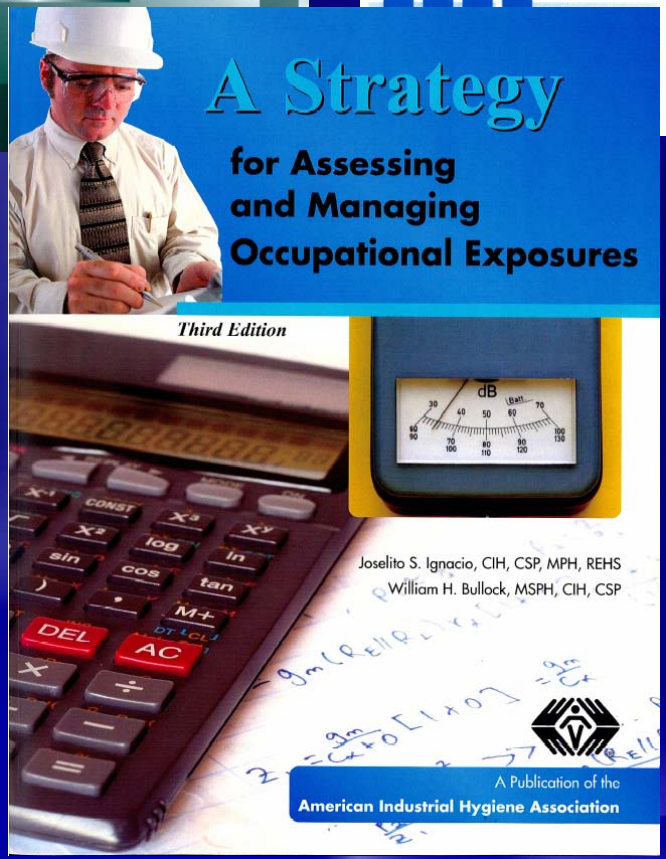
- Principles the same whether exposures occur
  - Yesterday
  - Today
  - Tomorrow

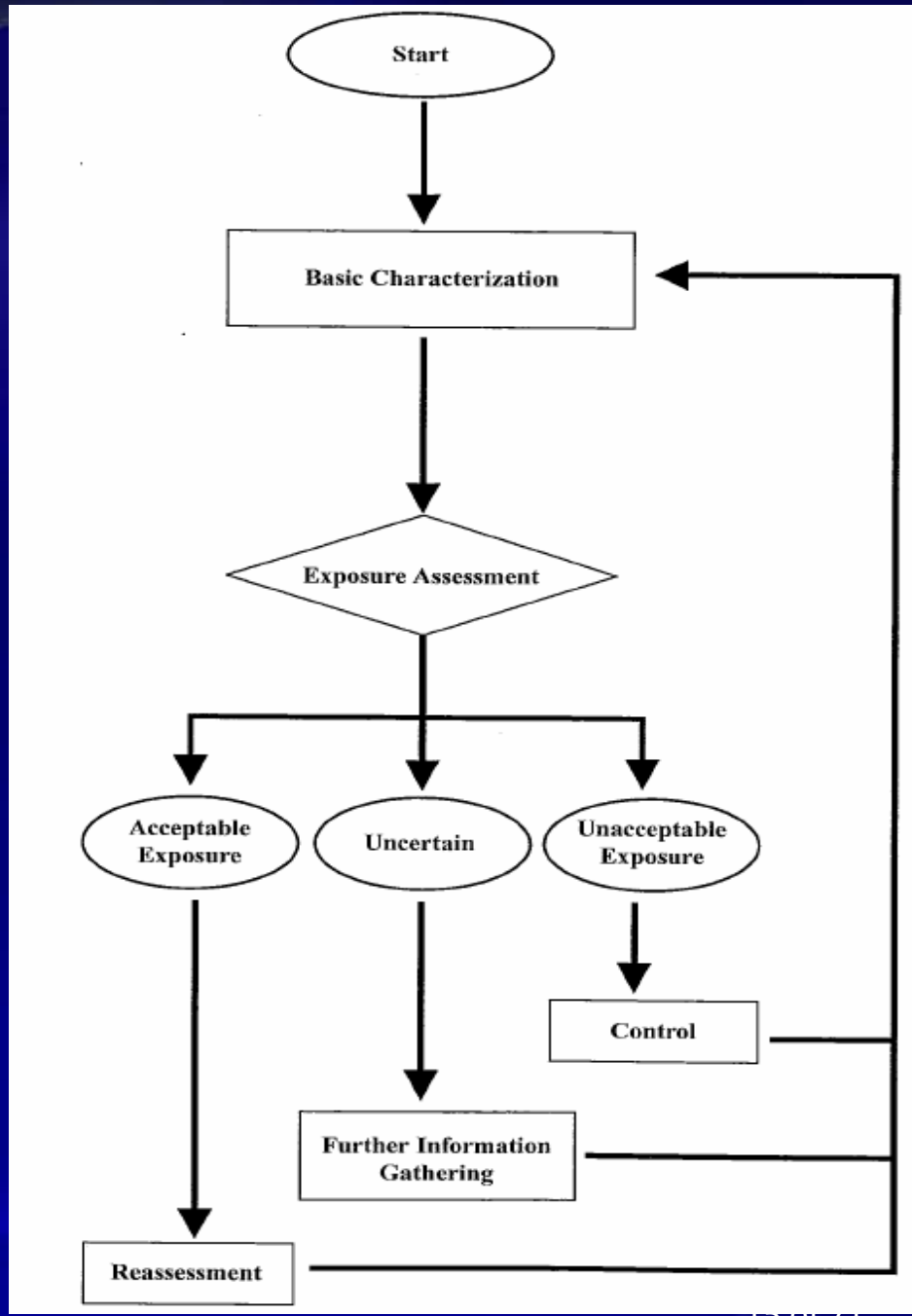
Standardization of REA methodology to Exposure Assessment Strategies Committee Paradigm

- Same principles
- Need for same vocabulary
  - Standard terminology from other sources added where necessary
- Additional reading and resources to back up common terminology and exposure assessment steps available in AIHA publications
- Universal, proven, methodology
- Has better chance of acceptance if following published and proven methodology


A Strategy for
Assessing and Managing
Occupational Exposures
Second Edition
John R. Mulhausen, Ph.D., CIH, and
Joseph Damiano, MS, CIH, CSP

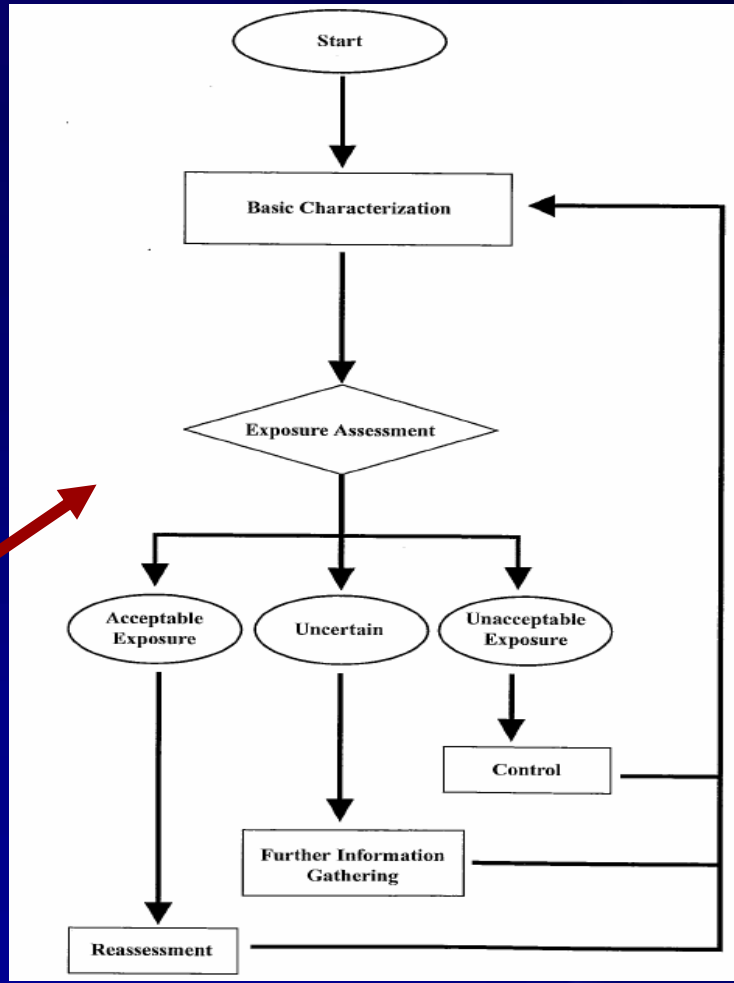

Mathematical Models for
Estimating Occupational
Exposure to Chemicals
AIHA
Exposure Assessment Strategies Committee
Modeling Subcommittee
Editor
Charles B. Keil, Ph.D., CIH
Contributing Authors
Wil F. ten Berge, Ph.D.
M. Cathy Fehrenbacher, CIH
Michael A. Jayjock, Ph.D., CIH
Charles B. Keil, Ph.D., CIH
Mark Nicas, Ph.D., CIH
Patricia H. Reinke


A Strategy
for Assessing
and Managing
Occupational Exposures
Third Edition
Joselito S. Ignacio, CIH, CSP, MPH, REHS
William H. Bullock, MSPH, CIH, CSP
A Publication of the
American Industrial Hygiene Association

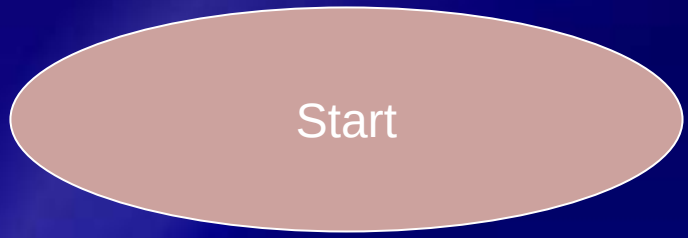

Start
Basic Characterization
Exposure Assessment
Acceptable Exposure
Uncertain
Unacceptable Exposure
Control
Further Information Gathering
Reassessment

Retrospective Exposure Assessment (REA) Twelve Step Methodology

- Based on the previous paradigm defined by Larry Birkner and others as a starting point
- Applicable to individuals or groups
- Derived from joint experience
- Emphasizes, follows, and expands on the most applicable aspects of "A Strategy for Assessing and Managing Occupational Exposures"



A Twelve Step (REA) Program for the Industrial Hygienist



1. **Define questions to be answered and establish goals**
2. **List the jobs and tasks that will be evaluated**

A Twelve Step (REA) Program for the Industrial Hygienist

Basic Characterization

3. **Determine all potential exposure pathways and routes of exposure**
4. **Assemble all available foundation data and evaluate the relationship between the foundation data and the target REA**
5. **Select analytic methods to be used and their associated outputs**

A Twelve Step (REA) Program for the Industrial Hygienist

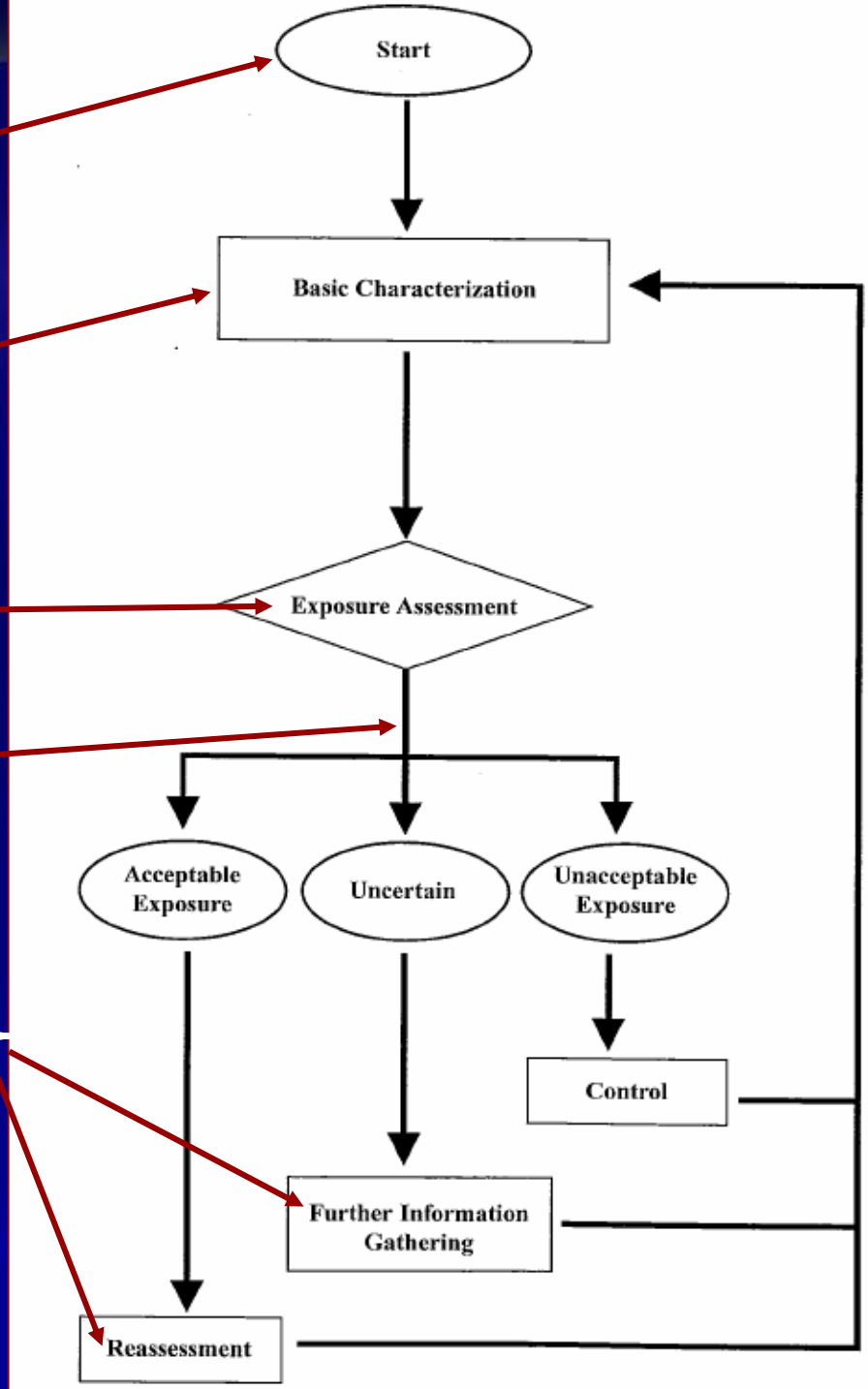
6. **Define Similar Exposure Groups (SEGs)**
7. **Determine Exposure Profiles for each SEG/ apply to individuals or groups**
8. **Compare Exposure Profiles with Benchmark Exposures for individuals or groups (or perform alternate risk assessment)**

A Twelve Step (REA) Program for the Industrial Hygienist

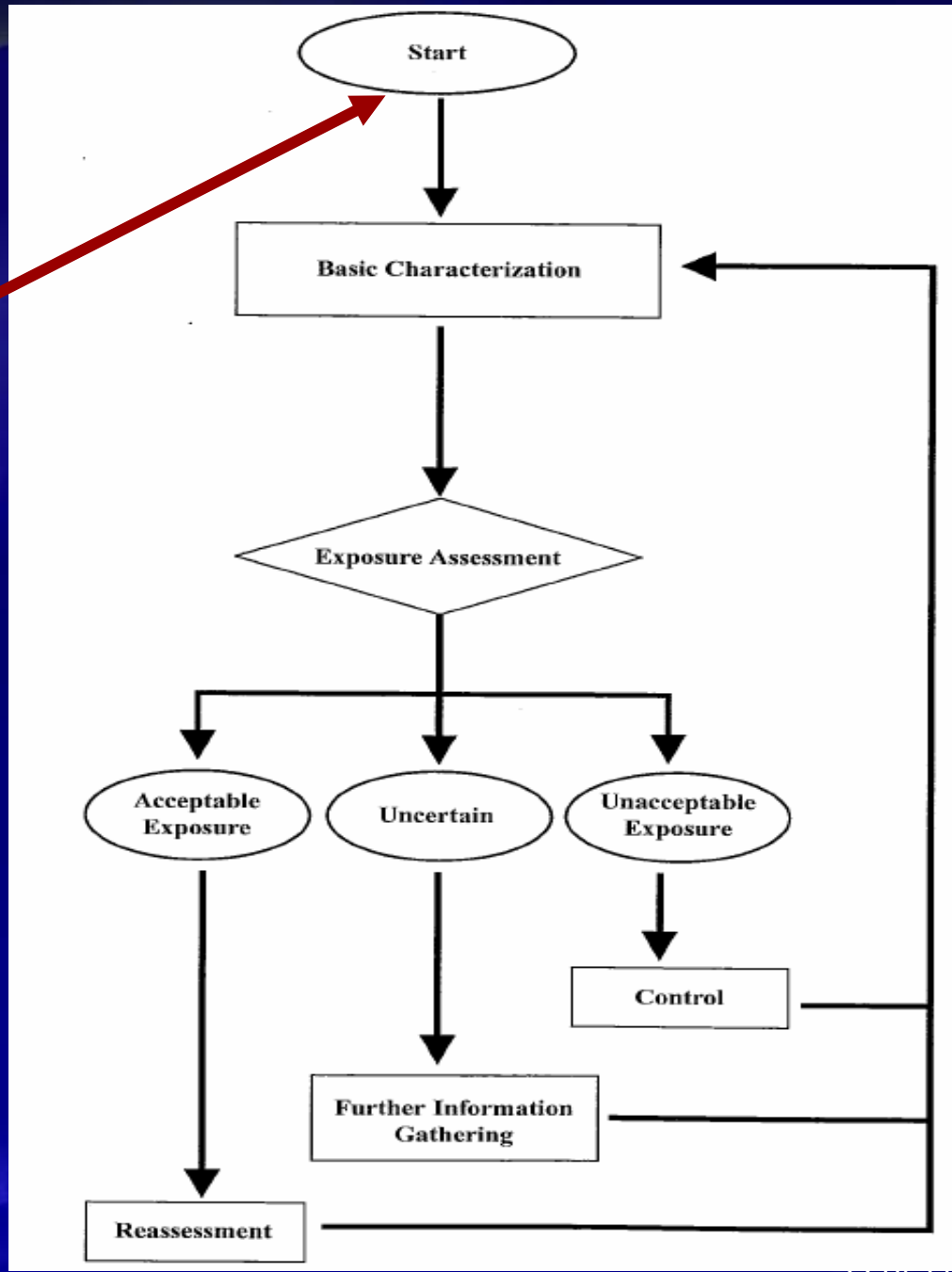
Further Information Gathering and Reassessment

9. **Identify, review, and evaluate biases, uncertainties, and assumptions**
10. **Perform sensitivity analysis and improve accuracy and precision of key exposure parameters as necessary**
11. **Validate assessment**
12. **Report results**

1. Define problem
2. List jobs and tasks
3. Exposure pathways
4. Gather Data
5. Select outputs
6. Define SEGs
7. Determine exposure profiles
8. Compare with benchmarks
9. Review biases, uncertainties, and assumptions
10. Sensitivity analysis/improve where necessary
11. Validate
12. Report



Define Problem



Start

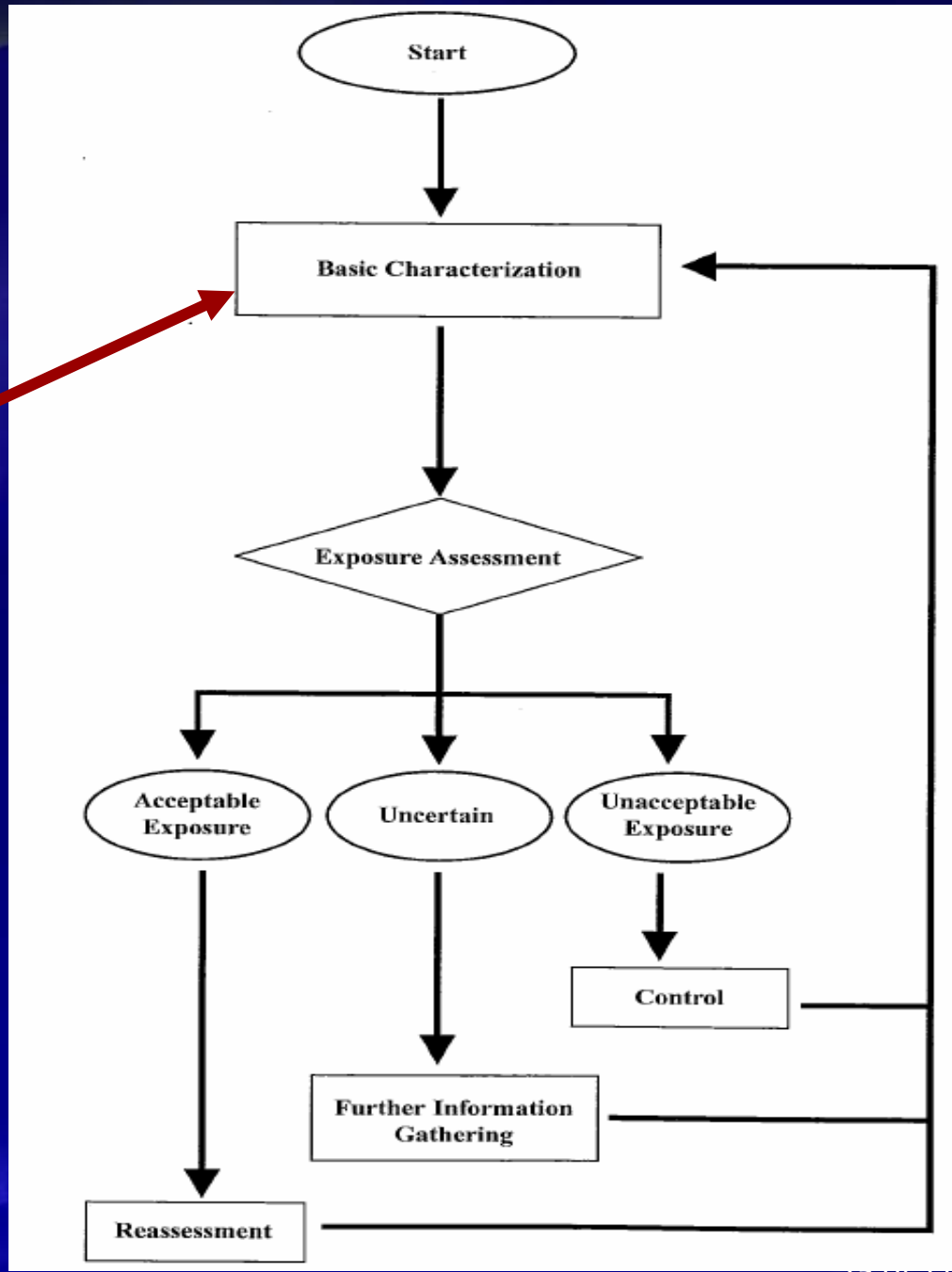
1. Define questions to be answered and establish goals
   - What is the purpose?
   - What is the hypothesis?
   - What information is needed to test the hypothesis?
   - Can I outline mentally or diagram an approach?
     - Review scope with appropriate stakeholders
     - Identify subjects, chemicals and/or agents to be evaluated
     - Define goals in writing if practical and possible

Start

2. **Define the jobs and tasks that will be evaluated (for each subject)**

- **Locations, processes, products, and time periods**
- **Probability of exposure should be included when considering whether a specific job or task needs to be included**

Collect and organize available information on the workplace, work force, agents, historical exposure data, biological monitoring data, etc.



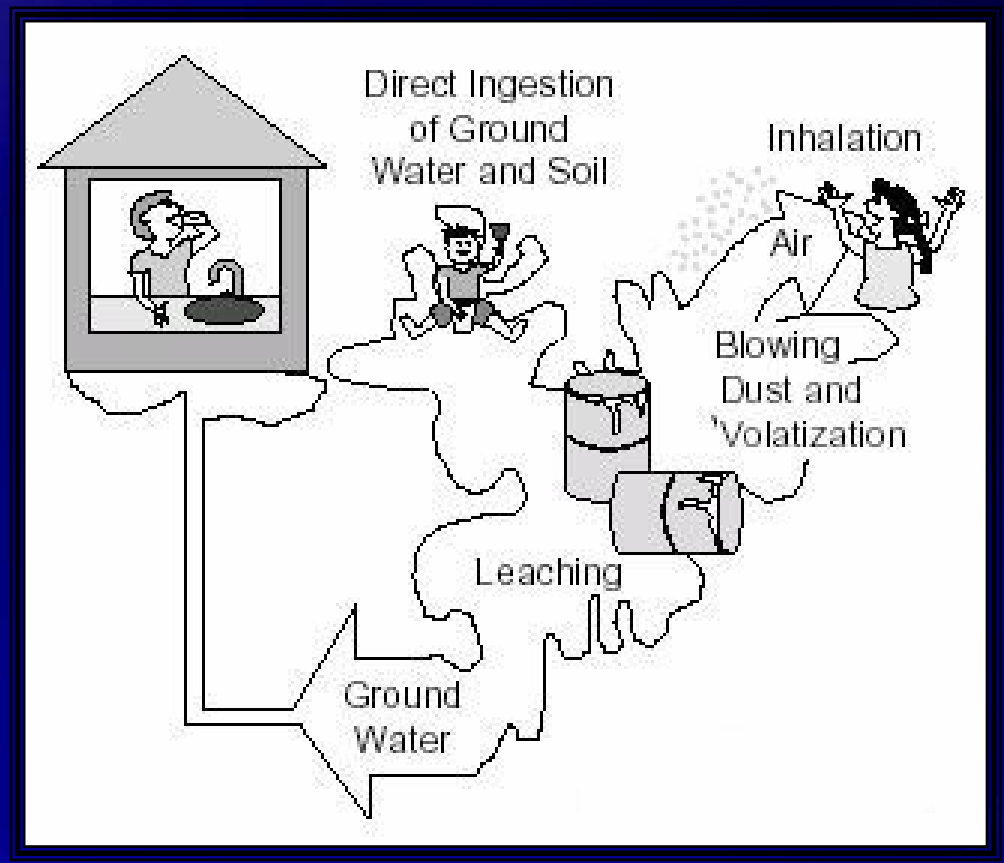
Basic Characterization

3. Determine and evaluate exposure pathways

- Obtain necessary information to define

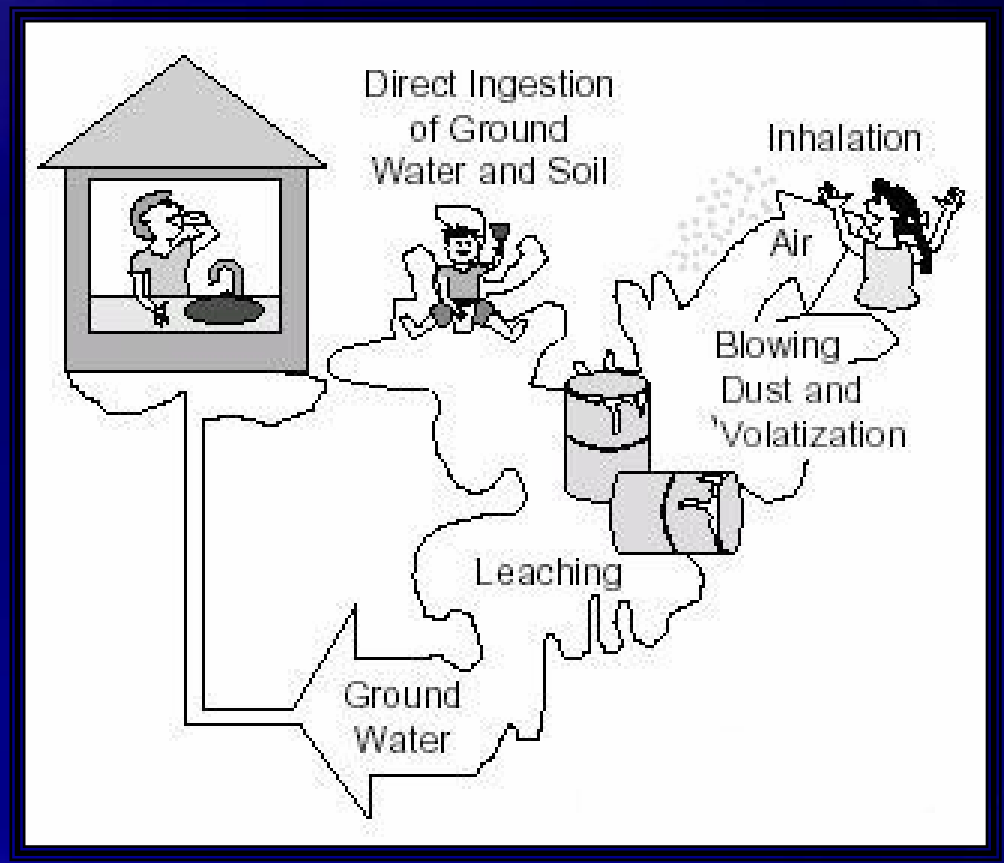
Exposure Pathways

- **Air**
- **Water**
- **Soil**
- **Direct Contact**



Routes of Exposure

- Direct Ingestion
  - Drinking Water
  - Soil
  - Dust
- Inhalation
  - Aerosols
  - Volatile Organics
- Dermal Contact



Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA

- What information is required?
- What information is irrelevant?
- Keep on track based on problem definition
  - Often testing a hypothesis
  - Often don't even need numerical output
  - Look for time saving methods
  - You may not need to consider all of the materials listed here

Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA

- Detail work histories
  - Employment, Union, Military, Social Security, etc. records
  - Interviews
  - Depositions of subject, co-workers, and others if related to legal work
  - Summaries of work and exposure histories usefully summarized in spreadsheet
    - Also allows convenient calculations for each exposure event

Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA
   - Obtain helpful records
     - Past monitoring data from colleagues, scientific literature, and government sources
     - Process flow charts
     - Process standards
     - Standard Operating Procedures
     - Production
     - Personnel
     - Medical / biological and pathological exposure indicators
     - Engineering
     - Environmental Reports
     - Management Reports
     - Etc.

Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA

- Conduct walkaround survey
- Interview available workers, managers, engineers, and medical and safety staff
- Obtain literature
  - Toxicological studies and published parameters
  - Thresholds (including Basis for TLVs)
  - OELs
  - Fate and transport parameters
  - Emerging issues
  - REA Methodologies
  - Epidemiological studies
  - Governmental environmental reports
  - MSDS

Helpful Interview Techniques

- Pre-designed forms and questions
- One-one in private
- Leading questions avoided
  - No interviewer suggestions of possible exposure points
  - Exposure points not included in analysis unless mentioned by multiple interviewees
  - Follow-up calls to most knowledgeable workers for final quantification estimates
  - Units of measure: drops, teaspoons, cups, quarts, gallons for spills/dermal contact
  - Pre-selected categories used to describe inhalation and aerosol exposures

Example of Standardized Interview Categories (for odor/symptoms)

Category 1. No smell or other noticeable effect

Category 2. Barely smell, no symptoms

Category 3. Identifiable odor, no symptoms

Category 4. Strong odor, no symptoms

Category 5. Overpowering odor/ had to leave area and/or noticeable physical symptoms such as headaches, giddiness, nausea, etc.

Individual Simple Exposure History Spreadsheet Example

Mr. Henry Jones Work History and Exposure Notes

Date Of Birth: October 1, 1922
Date of Death: N/A

Employment Dates	Employer	Location	Occupation	Job Description	Work Environment	PPE	Manu.	Product	Duration and Frequency of Exposure
Early Years: 1927-1945 Cpp2-3	N/A	St. Clair Shores, Michigan Ap12; Cp2	N/A	Mr. Jones said he first started helping his father in the roofing and sheet metal business when he was 10 years old Ap18; Bp20.	Mr. Jones was born, resided, and attended school in St. Clair Shores, MI and completed the 12th grade in 1945. He attended State University to study accounting and business Ap12-13; Bp15; Cp3.	None Ap64; Bp42	(See below)	(See below)	His attendance at State University was part-time for about a year and a half Ap13. He worked for his father part-time and during the summers from about 1937-1945 App17-18, 26.
				When first starting work with his father he cut pieces from rolls of asbestos insulation that were then glued onto the coal furnace pipes (ducts) App56-57; Bp33.	His father had his own business, Standard Sheet Metal, from 1924 to 1949, and did sheet metal, roofing, heating, siding, and some construction work Ap14-17. The work they did was almost all residential Ap50. The furnace pipe insulation rolls were about 12 inches in diameter and 30 inches long. The insulation was a woven, textile material, about 1/32 inch thick with little dimples App57-58. The manufacturer names he recalled were associated in general with his residential work in the Detroit area, and he said they may not have been specific to these materials App58-59.		Acme	Woven duct insulation/ asbestos paper	He used the furnace insulation material from 1937 up to about the beginning of WWII (1940-41) App57-58. Over his 30 years of installing furnaces (continuing into the sections below, as well), Mr. Pollock estimated that he did 500 jobs in the heating business associated with furnace installations Ap84. When later discussing this career-wide total he was told that the numbers he had talked about for various brands totaled 410 residential furnaces and about 105 commercial furnaces. He said that number might be high, but then said that when times were good, he estimated he did 20 to 30 units a year Ap262. Later yet he mentioned installing 20 new furnaces per year for 20 years Bp42. He estimated that 60% of his furnace jobs involved some disturbing of, or exposure to asbestos components in one way or another Bpp43-44.
				No further information.	The glue they used to stick the asbestos paper to the furnace pipe was a white paste, that was used on "both sides of the pipe" App57-58.		Didn't recall Ap58	Paste	No further information.
				He used asbestos cement when assisting his father putting the units (sections) of coal furnaces together. He smeared it on the rings using a putty knife App61-62, 209-210.	This cement was used only on the old coal furnaces, not on the later oil-fired furnaces Ap65. He recalled a Strong Man as a logo on the furnace cement Ap86. The furnace cement was black and came in a can. It was not dusty when applied App210-211.		He Man (logo) Ap86	Asbestos cement	He assisted with coal furnaces when he got older, but before WWII, probably in 1938-39 through 1940-41 App62, 209.
				They put asbestos rope on each ring (of the furnace), and from the heat exchanger to the flue Ap62.	No further information.		Not asked	Asbestos rope	No further information.
				He recalled some work with his father doing asbestos siding. He said he cut, punched holes, nailed the siding, and put sealant between the lap joints. He used a hand-operated machine that was like a large paper-cutter to cut this material App59, 212-218, 223; Bpp33, 60-63. He used a broom & dust pan to clean up the residue from cutting the siding material, then shoveled it into a bucket, creating more dust Bp62.	The material he recalled installing was an asbestos shingle-type siding Ap59. He also mentioned a "brick siding" made by the same manufacturers Ap213; Bpp60-62.		Best Job	Siding	He mentioned this being fill-in type work on a house Ap59. Since the work was piecemeal it took a long time, but would have been about 2 weeks total time to install the 25 to 30 individual asbestos siding shingles App215, 217. Later he said siding was put on 2 other houses down the street besides the family home Ap214.
				He did his first roofing job, by himself, when he was 10½ to 11 years old App18, 220.	He used CertainTeed shingles to do an "11-square" job (i.e. 1100 sq. ft.). These were three-tabbed shingles that took four nails per shingle App220-222. (Note: A number of manufacturers of cements, insulations, roofing materials, and mastics that were not mentioned in the depositions, were listed for this timeframe and beyond, in the Plaintiff's Discovery Brochure Epp3-4.)		All Roof	Roof shingles	He completed the job in 2 days Ap220.

Individual More Detailed Chemical Exposure Spreadsheet Example

James Henry Work and Chemical Exposure Summary Notes

Born December 15, 1946. Never smoked cigarettes. Non-inhaling pipe smoker for 30 years (p4). Light alcohol consumption.
Note: Mr. Henry claimed to have worked double shifts during about 80% of his career

Year	Employer	Occupation	Work Area/Location	Job Duties	Work Environment
Unknown	Childhood hobby			As a child, Mr. Henry built model airplanes. Occasionally, he used model airplane glue which contains toluene and diketone precursors (n-hexane, n-heptane, MEK, etc). (p3)	
1965 (p20)	Davis Bakery (p20)	Unknown		Made doughnuts	Not discussed.
1965 (p20)	Plaster Ad Company	Labor	Shipping	Crated plaster crafts into wooden boxes for shipping.	Not discussed.
1966	Foundry	Shipping clerk	Warehouseman?	Crated pot belly stoves for shipping.	Not discussed.
1966-68 (p5,20,21) (tele. 11-18-'03 for clarifications)	U.S.Army	Power Plant Mechanic Mechanized Infantry.	Fort Belvoir, Virginia Germany	Army School Field Operations	
Feb-68 (p21)	Ashley Railroad	Apprentice Mechanic (p 24)	South Centerville Shop Parts reclamation Machine Gang area (Il, p.1)	Disassembled parts for cleaning and re-assembling. (p24) Across from Machine Gang area where he worked, steam wreckers were being converted to diesel. Asbestos was being stripped off of the boilers, 50 to 75 feet away except he worked directly in the stripping area about once per week during the first two or three months. (Il. p.1)	
		Apprentice (p24)		Bystander exposure to Acme cleaner.	Approximately 25 away from this work station, was Heavy Repair where locomotives were sprayed with Acme with a large (approx. 250 gal) spray tank on a daily basis (p42). Although the actual spraying would only last 3-4 hours, the vapors would linger. (p42)
1969		Apprentice (p24)	South Centerville Shop Maintenance Gang	Learning to weld and subbing out to the maintenance gang. (p43)	
		Apprentice (IIp1) years and beyon	Apprenticeship welding training Welding and torching as a mechanic	Torching and welding	Ripped off asbestos from asbestos 3 or 4 foot asbestos rolls for (a.) protecting surrounding areas from damage during torching or welding, or (b.) to control cooling times after

Individual Chemical Exposure Spreadsheet Cont'd.

Description, Extent, and Nature of	Frequency and Duration of Inhalation Exposures	Chemical and/or Physical Agents	Description, Extent and Nature of Dermal Exposures	Frequency and Duration of Dermal Exposures	Chemical Agents	Personal Protective Equipment	Comments
N/A	Approx. 3 years part time	N/A	N/A	Three years part time			
N/A	Approx. 1.5 months. (p20)	N/A	N/A	Approx. 2 months. (p20)			
N/A	Approx. 1 month. (p20)	N/A	N/A	Approx. 1 month. (p20)			
Constant exposure to Acme cleaner.	One year (p43)	Acme cleaner (p31) Asbestos insulation, two to three months, intermittently.	Hands in the solvent 2 to 3 hours per day. (p39,40) When his hands were in the sol- he described the odor as 3. (p41)	One year (p43)	Acme cleaner (p31)		
Described the odor as a 4. (p42)	Daily.	Acme cleaner. (p43)					
Occasional exposure to solvents. (p43) Odor described as a pervasive 3. (p43)	Worked three months during apprenticeship full time as welder. During this time on cranes, wrapped everything in asbestos from rolls for protection. Otherwise, asbestos ripped off of roll	Acme cleaner and mineral spirits. (p43) Asbestos sheets					

Basic Characterization

4. **Assemble all available foundation data and evaluate the relationship between the data and the target REA**

- **Evaluate past monitoring data**
  - **Purpose?**
  - **Screening samples?**
  - **Worst-case?**
  - **Personal samples?**
  - **Area sample?**
  - **Monitoring Duration?**
  - **Number of data points?**
  - **Methods?**
  - **Other?**

Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA

- Perform data quality review, especially of collected monitoring data
  - Is the purpose consistent with objectively evaluating subject's exposures?
  - Are the work practices known and similar?
  - Were the ventilation conditions similar to those of the subject or were there a wide variety of ventilation conditions included?
  - Were "worst-case" or peak exposures being determined?
  - How do sampling times compare?
  - Are there sufficient data points?

Basic Characterization

4. Assemble all available foundation data and evaluate the relationship between the data and the target REA

- Perform data quality review, especially of collected monitoring data
  - Are employee-to-employee variations included?
  - Are day-to-day variations included in data set?
  - Are the sampling and analytical methods appropriate?
  - Is the data considered to be representative of an SEG that would include the subject or is it adequate surrogate data?
  - Can the data be included in a single population statistical summary?
  - Can the data be utilized with caveats and qualifications?
  - Other considerations?

Combining sampling results from diverse studies typically results in a log-normally distributed population that can be described with its own statistics

- Higher than usual GSDs
- But highly inclusive of diverse work practices and ventilation conditions
- Examples

Better to have SEG or surrogate data too inclusive than too restricted, but results in more variability in exposure estimate

From A Strategy for Assessing and Managing Occupational Exposures, 3rd Edition (AIHA), 2006

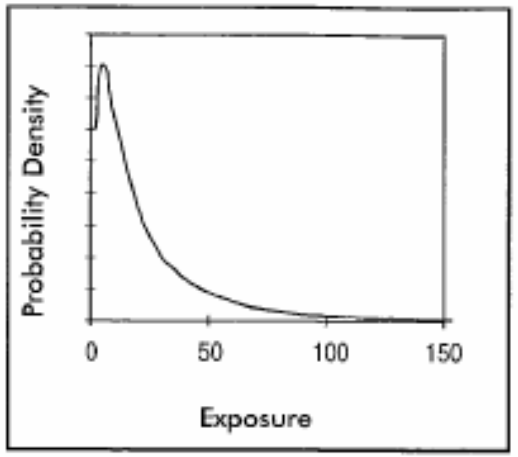


Figure V.1a — SEG exposure profile.

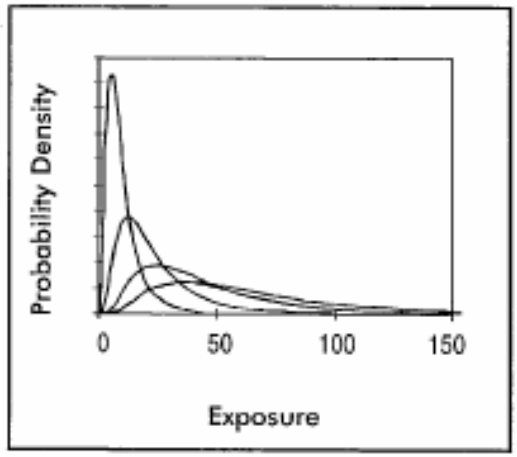


Figure V.1b — Individual worker exposure profiles.

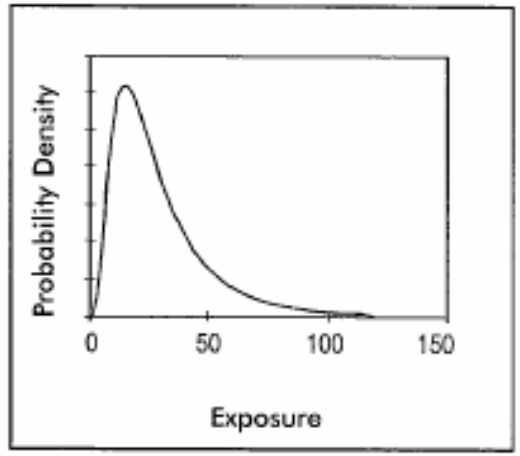
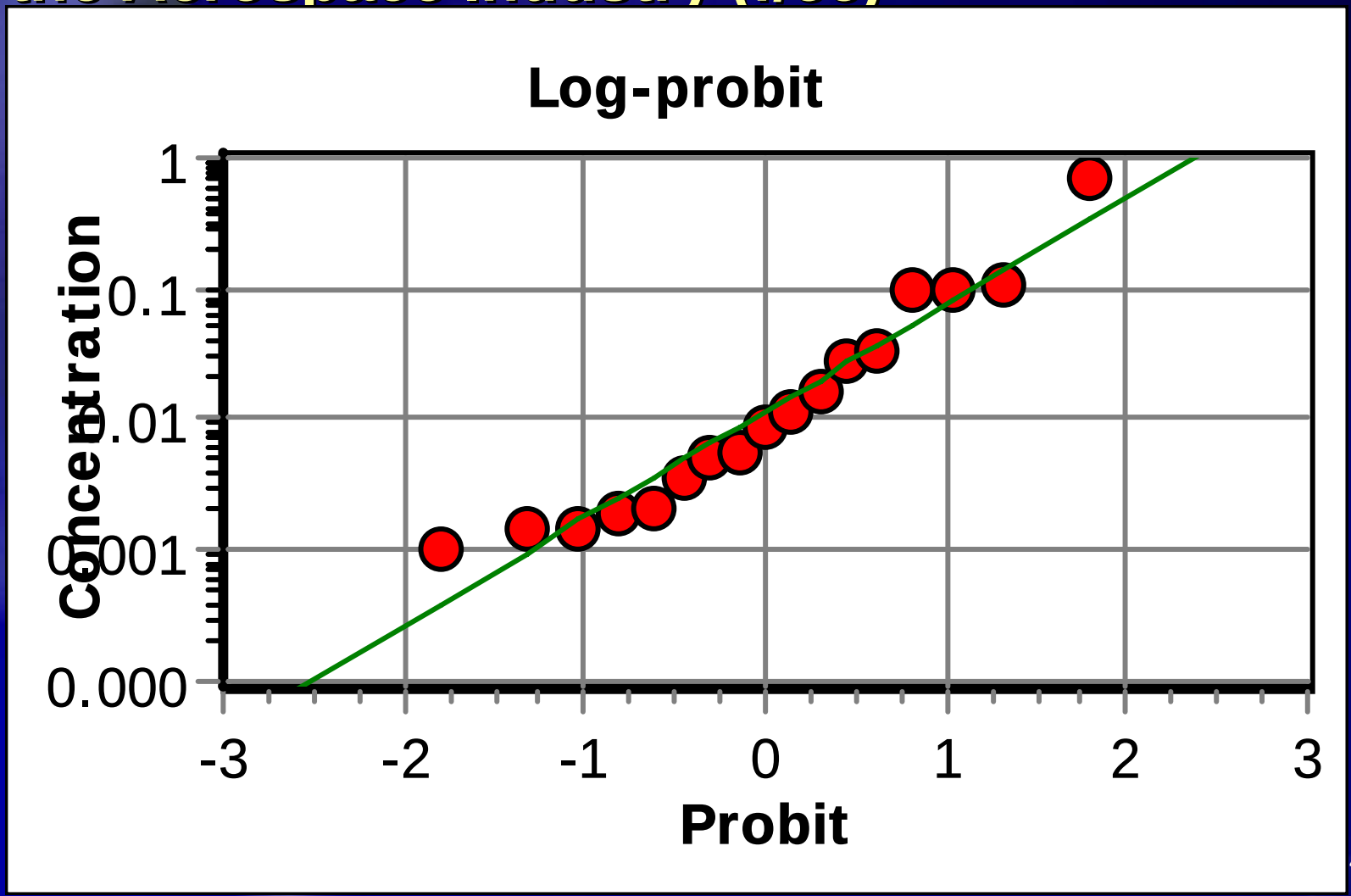


Figure V.1c — Distribution of worker arithmetic mean exposures.

Range of Air Concentration Measurements for Sanding and Machining Asbestos-Containing Adhesive (representing different processes) in the Aerospace Industry (f/cc)



Basic Characterization

5. Determine analytic methods to be used and their associated outputs

- Is temporal exposure or total exposure information the most relevant?
- Do I even need the output to consist of numerical information?
- If numerical, deterministic or stochastic?

Basic Characterization

5. Determine analytic methods to be used and their associated outputs

- Exposure or dose?
- Units?
- Screening methods to be used?

Basic Characterization

5. Determine analytic methods to be used and their associated outputs

- Qualitative?
  - Low, Medium, High
  - Less than or greater than various benchmarks
  - Other descriptive
- Semi-quantitative?
  - Point estimate, deterministic, often RME
- Quantitative within ranges?
  - Deterministic
  - Stochastic

Total Exposure – Haber's Rule

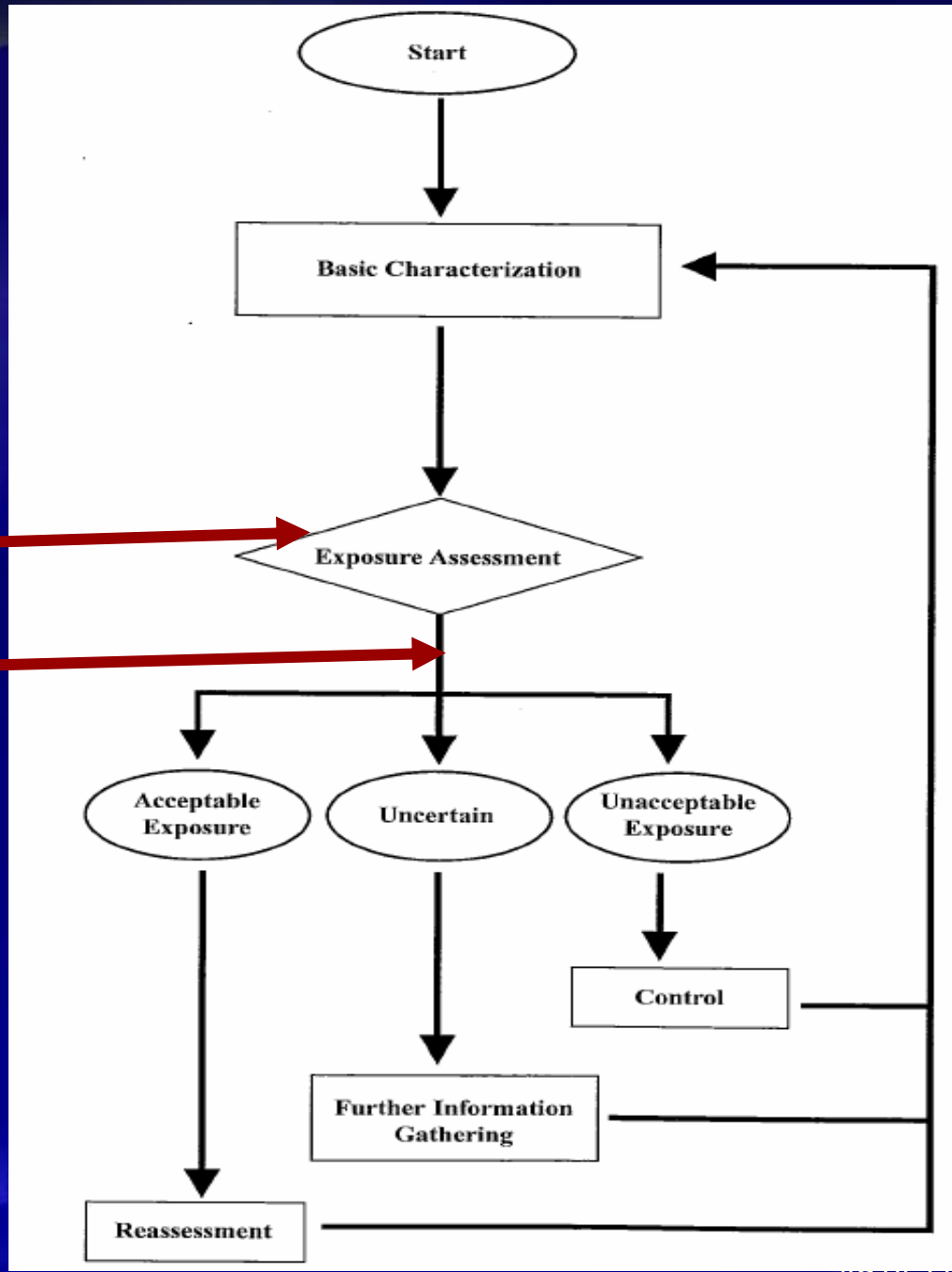
- The concept that the product of the concentration (C) of a substance and the length of time (t) it is administered produces a fixed level of effect for a given endpoint has been ascribed to Fritz Haber, who was a German scientist in the early 1900s
- Often utilized in epidemiological studies for substances that produce health effects from long-term exposures such as cancer or pneumoconiosis to establish a dose-response relationship
- Concept often employed in risk assessment of chronic exposures

- Total Exposure = C * t

Total Exposure – Haber's Rule

- Average concentration times duration can be determined for differing types of exposure to the same substance in a person's lifetime
- Each exposure type can be defined as an exposure event
- The sum of the total exposure for all exposure events in a person's lifetime results in his cumulative lifetime exposure
  - Or for a product, location, job, etc.

Define Similar Exposure Groups (SEGs), determine Exposure Profiles, and compare with Benchmark Exposures (or perform alternate risk assessment)



Exposure Assessment

6. Define Similar Exposure Groups

- Similar exposure groups (SEGs) are groups of workers having the same general exposure profile for the agent(s) being studied because of the similarity and frequency of the tasks they perform, the materials and processes with which they work, and the similarity of the way they perform the tasks
- SEGs (or surrogate groups) determined for (a.) sources of data and (b.) classification of subjects for REA
- Defined by environmental agent, process, job classification, and task

Exposure Assessment

7. Determine Exposure Profiles for each SEG/ apply to individuals or groups
   - Set up equation(s) that represent exposures or doses of interest that include all exposure parameters
   - Basic form includes C * t if total exposure or dose is being determined (for each exposure event)
     - Based on specific intensity, typical duration, average frequency, number of years of occurrence, etc.
     - Input singe-valued exposure parameters if determinant
     - If stochastic, also input underlying exposure parameter variability (probability distribution functions) in spreadsheet/stochastic program such as Monte Carlo.
     - Include modifying factors (with associated variability)
     - Some exposure parameter considerations follow

Exposure Assessment

7. Determine Exposure Profiles for each SEG/ apply to individuals or groups
   - Utilize past personal monitoring data
     - Screening sample?
     - Area sample?
     - Same SEG/ data representative?
     - Applicable monitoring duration?
     - Statistical summary possible?
     - Sufficient number of data points?
   - Or Use Surrogate Data
     - Another agent?
     - Same agent, another operation?
       - Known probability distribution/statistics?
       - Likely inclusivity of subject(s)' exposures?

Exposure Assessment

7. Determine Exposure Profiles for each SEG/ apply to individuals or groups

- Perform modeling based on physical and chemical properties?
  - Asbestos example: friability
  - AIHA *Mathematical Models for Estimating Occupational* Exposures to Chemicals
  - USEPA guidance
  - Pharmacokinetic models
    - e.g., IEUBK for Lead
  - Simulation Testing

Exposure Assessment

7. Determine Exposure Profiles for each SEG/ apply to individuals or groups

- **Modifying Factors?**
  - **Primary or secondarily exposed worker?**
  - **Ventilation?**
    - **Ranges in literature**
    - **Two Zone Model, etc.**
  - **Underlying process associated with monitoring data compared with subject work activity**
  - **Contaminant concentration differences**
  - **Usage rates**
  - **Etc.**

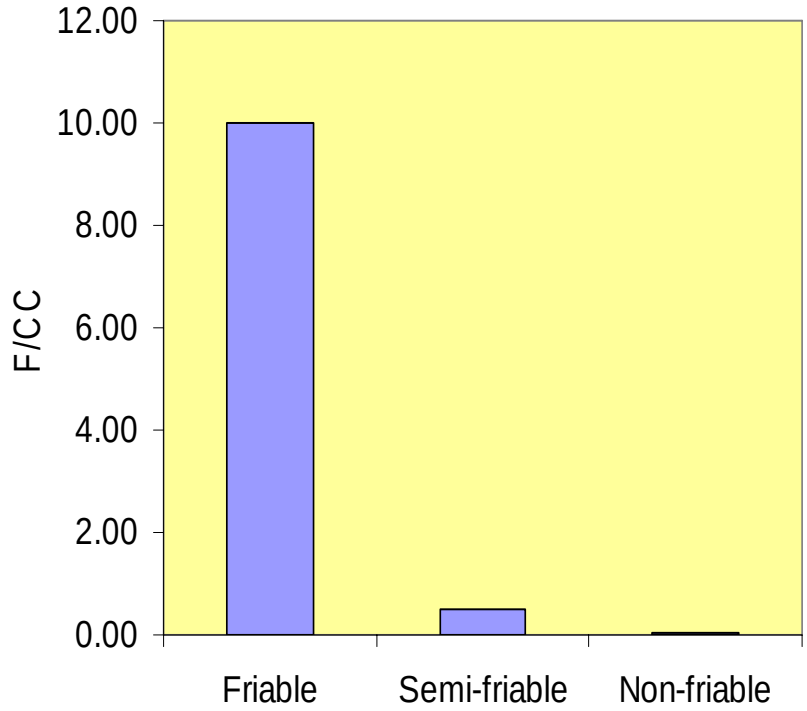
Exposure Models can be simple

“Exposure estimates are generally based on 1.) modeling (physical-chemical properties and/or environmental information) and/or process usage information; 2) surrogate data (from another agent, from another operation); and 3) monitoring data (personal, area). In the early cycles through the exposure assessment process, little monitoring data typically are available. The initial exposure assessments are therefore based on modeling and surrogate data. In most exposure assessment programs, the majority of assessments can be resolved in this manner – the majority of those are likely to be based on unsophisticated or crude modeling. For example, every time an industrial hygienist reviews a situation and judges the amount of chemical used to be too low to result in significant exposure, he or she has performed exposure modeling – even if it is a crude model performed quickly in one’s head.”

-- John R. Mulhausen, Ph.D., CIH (*Mathematical Models for Estimating Occupational Exposures to Chemicals, 2000*)

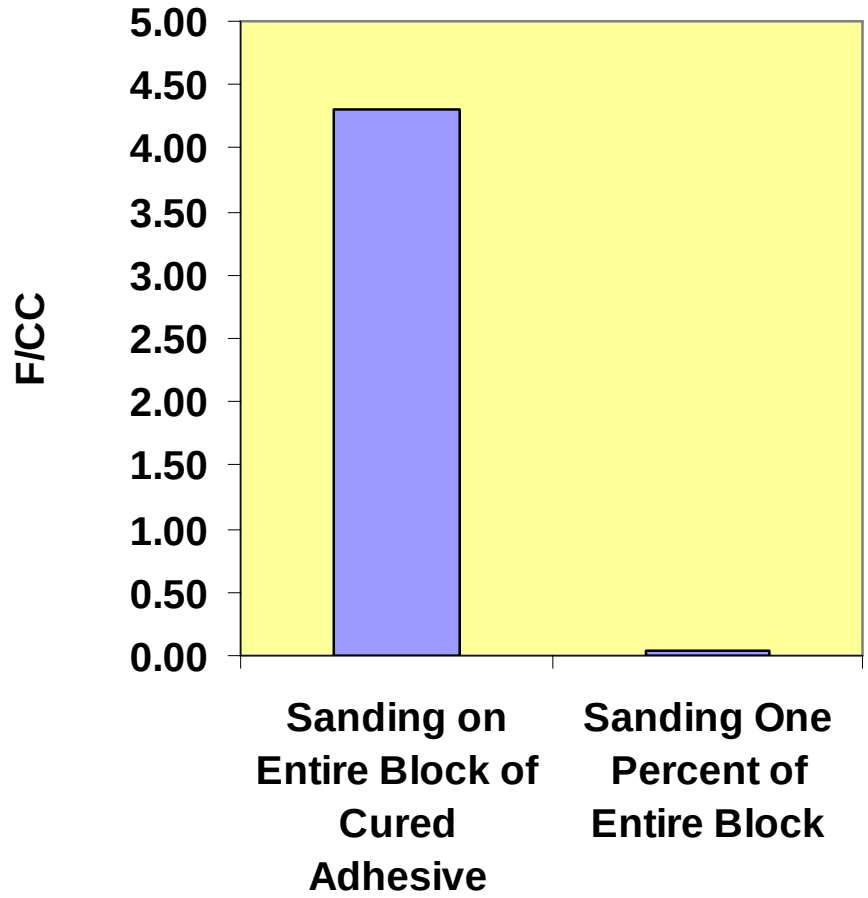
Simple Model: Exposure Categories of Asbestos-Containing Products -- Friability

- **Friable (High)**
  - **Raw asbestos, pipe insulation, insulation cements, dry wall joint compound**
  - **> 1 to 20 f/cc, TWA**
- **Semi-friable (Medium)**
  - **Asbestos cloth, Asbestos Paper Products**
  - **<0.1 to 1 f/cc, TWA**
- **Non-friable (Low)**
  - **Encapsulated materials, floor tiles, friction products, adhesives, (hand tools), gaskets**
  - **< 0.01 to 0.1 f/cc, TWA**



Modifying Factors Example: Effect of sanding or machining small amounts of asbestos-containing adhesive

- **Power sanding a larger amount of adhesive, a block of pure cured adhesive without ventilation: up to 4.3 f/cc**
- **If one percent or less of the same material were sanded (such as a bond line), one would expect less than around 0.043 f/cc**



Exposure Assessment

8. Compare Exposure Profiles with Benchmark Exposures for individuals or groups (or perform alternate risk assessment)

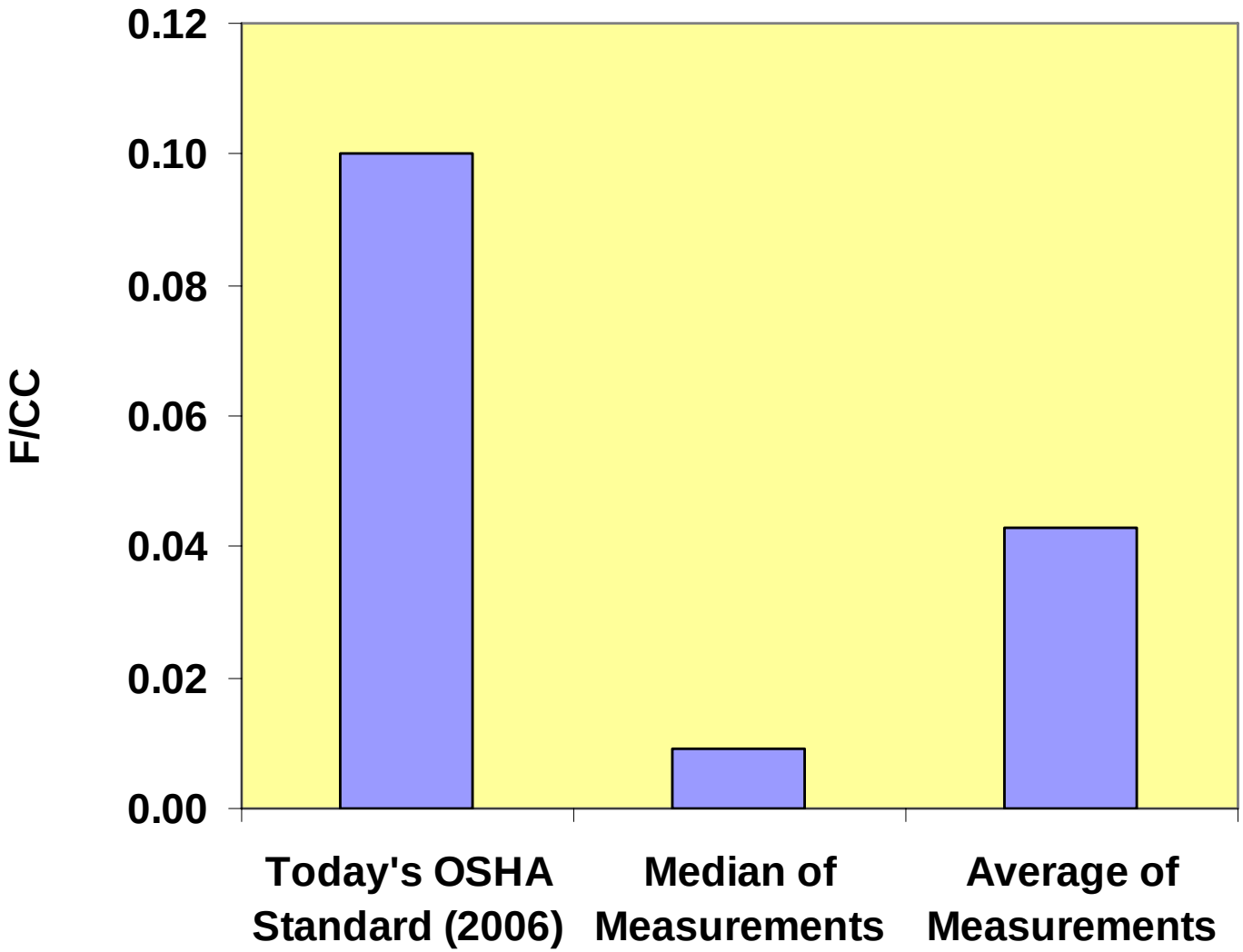
- Occupational exposure limits
  - Expressed as 8 hour TWA
  - Expressed as Ceiling
  - mg/m^3, ppm, f/cc, etc.
- Occupational exposure limits expressed as total exposures
  - e.g., 45 years X OEL
  - Units of mg/m^3 years, ppm years, f/cc years, etc.

Exposure Assessment

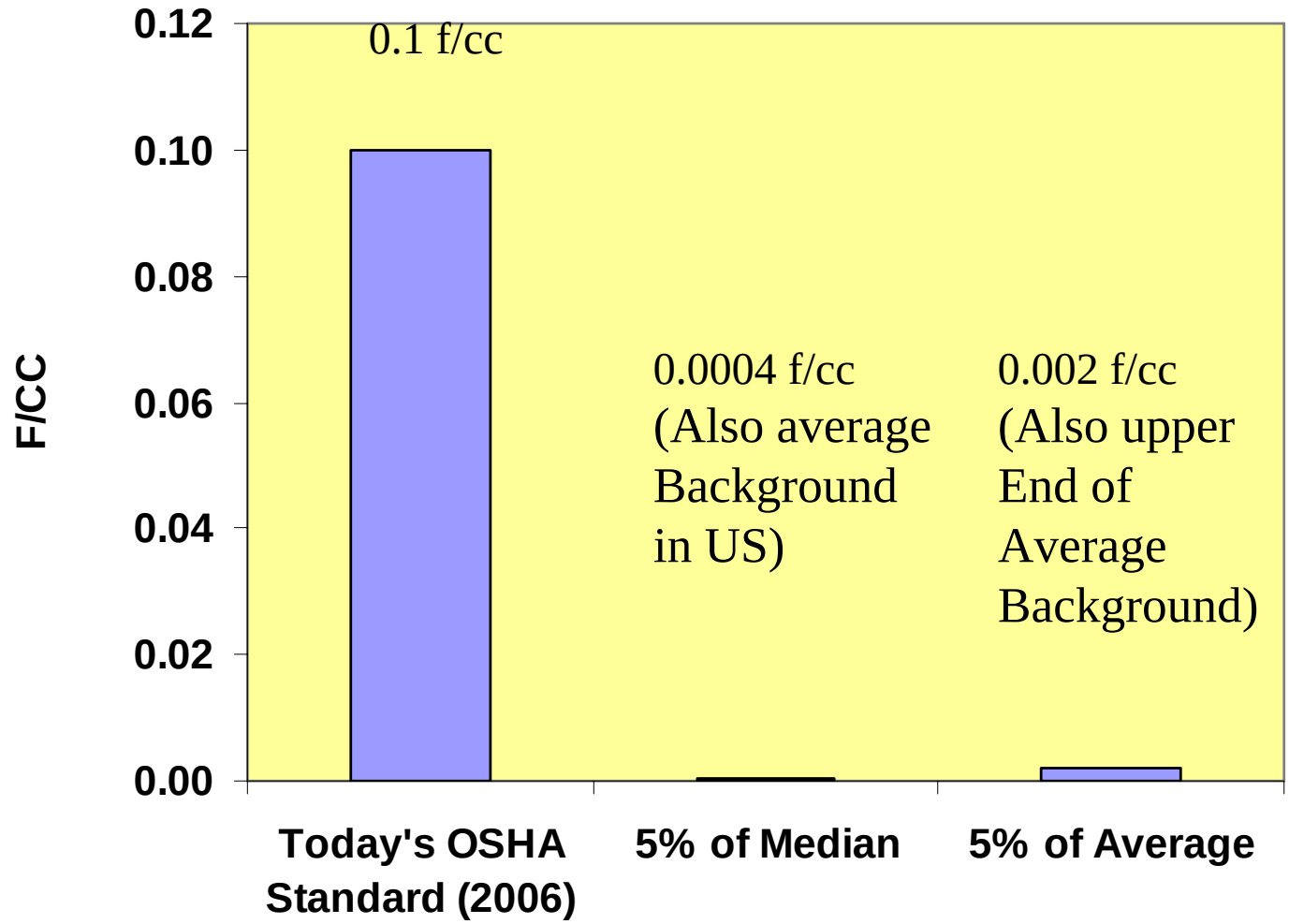
8. Compare Exposure Profiles with Benchmark Exposures for individuals or groups (or perform alternate risk assessment)

- Disease Thresholds?
  - Expressed as total exposures
- Typical, total, lifetime ambient background?
- Less than 10% of benchmark?
- Describe exposure qualitatively in terms of risk?
- Perform USEPA-style or other type of risk assessment?

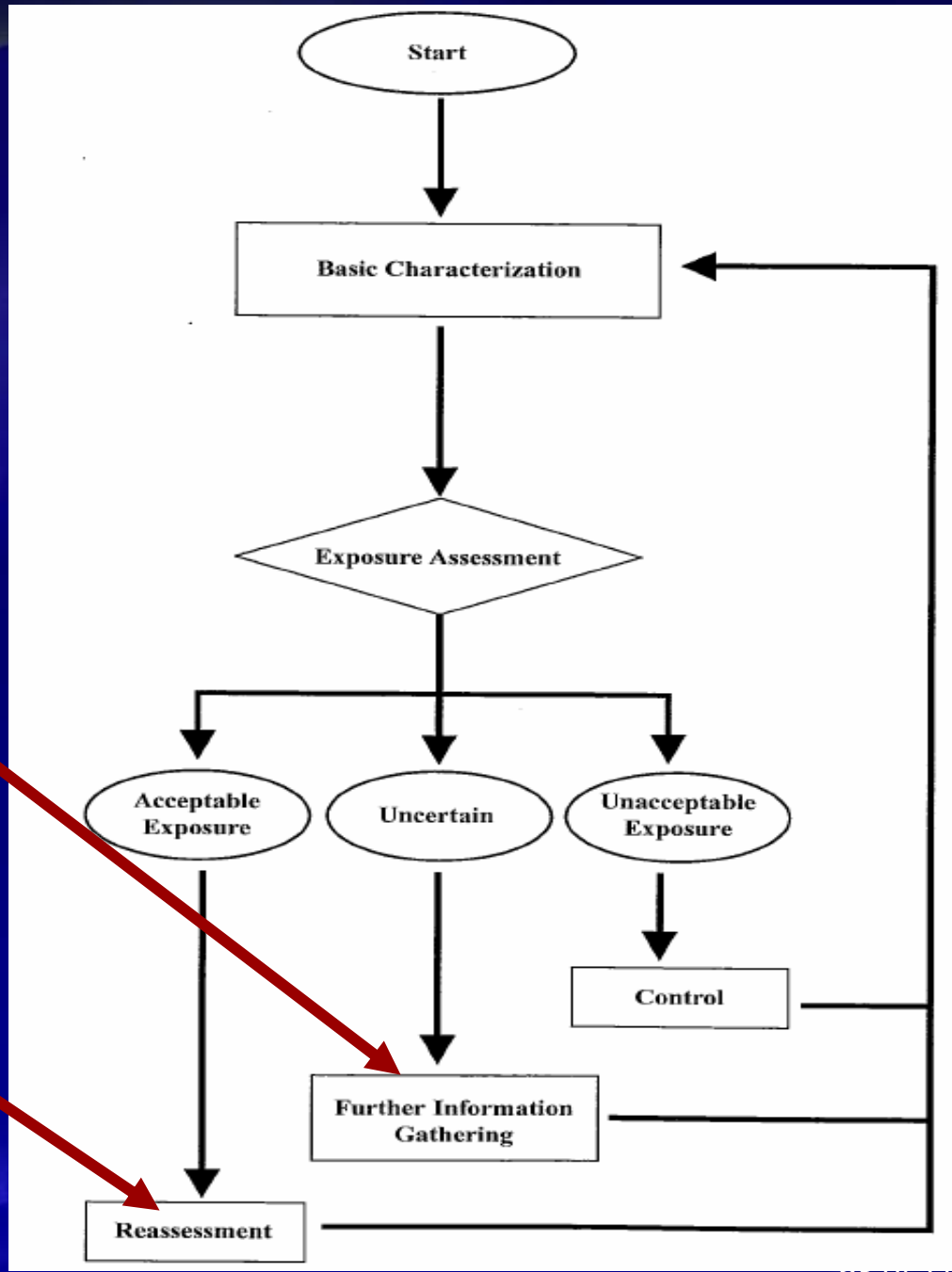
Exposure Statistics Associated with all Measurements of Sanding of Asbestos-Containing Adhesives



Indirect Exposures from Sanding Adhesives



Identify biases and assumptions, exposure assessment drivers, validate, and make improvements where necessary



Further Information Gathering/ Re-Assessment

9. Identify, review, and evaluate biases, uncertainties, and assumptions

- Are outputs reasonable?
- Is there a need for revisions?
- Perform uncertainty analysis
  - USEPA guidance can be helpful

Further Information Gathering/ Re-Assessment

10. Perform sensitivity analysis and improve accuracy and precision of key exposure parameters as necessary

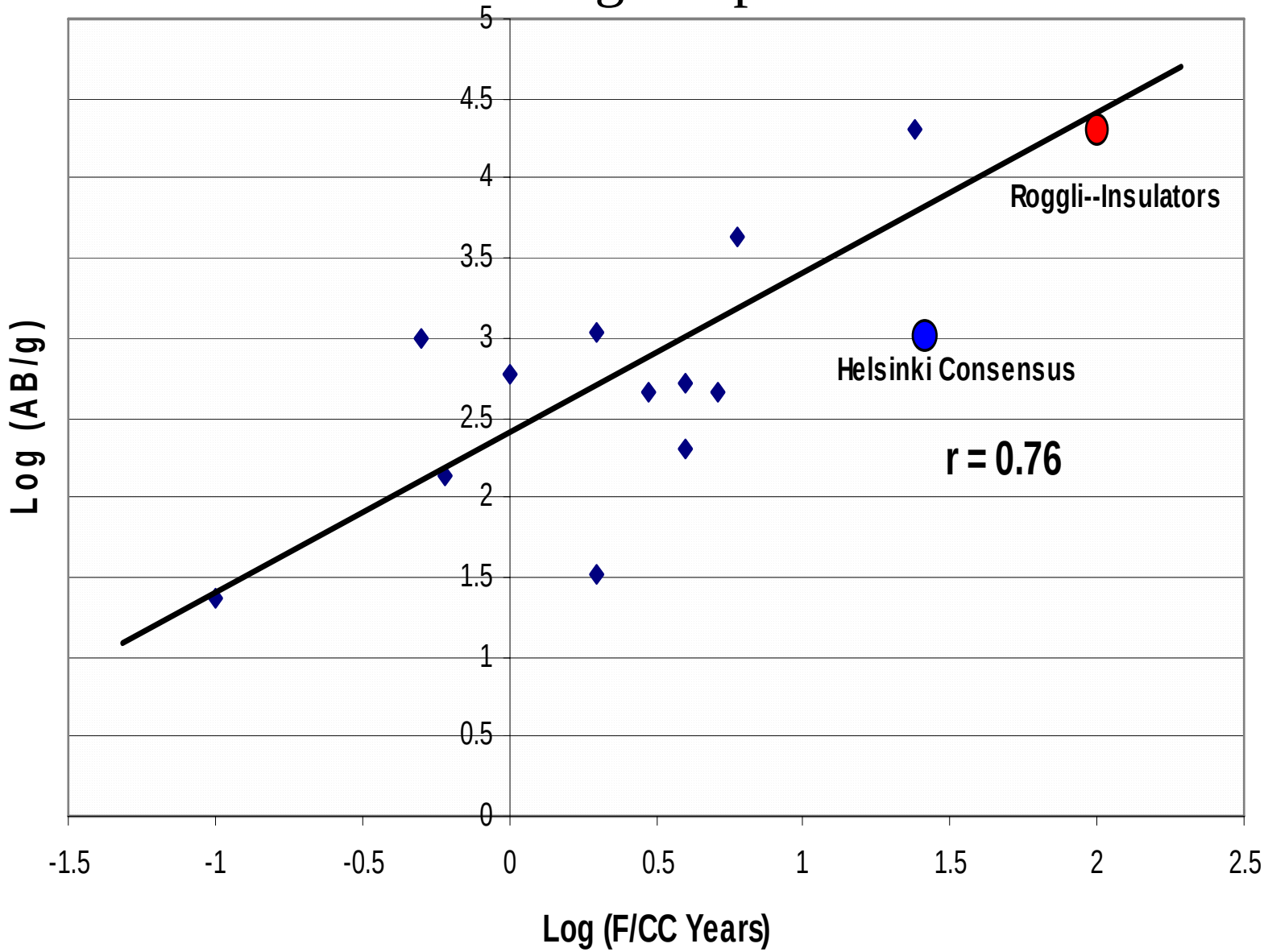
- Sensitivity analysis can be automated in stochastic programs (afternoon session)
- Which non-sensitive exposure parameters can be laid to rest after screening-level analysis?
- Need for revision of most sensitive exposure parameters?

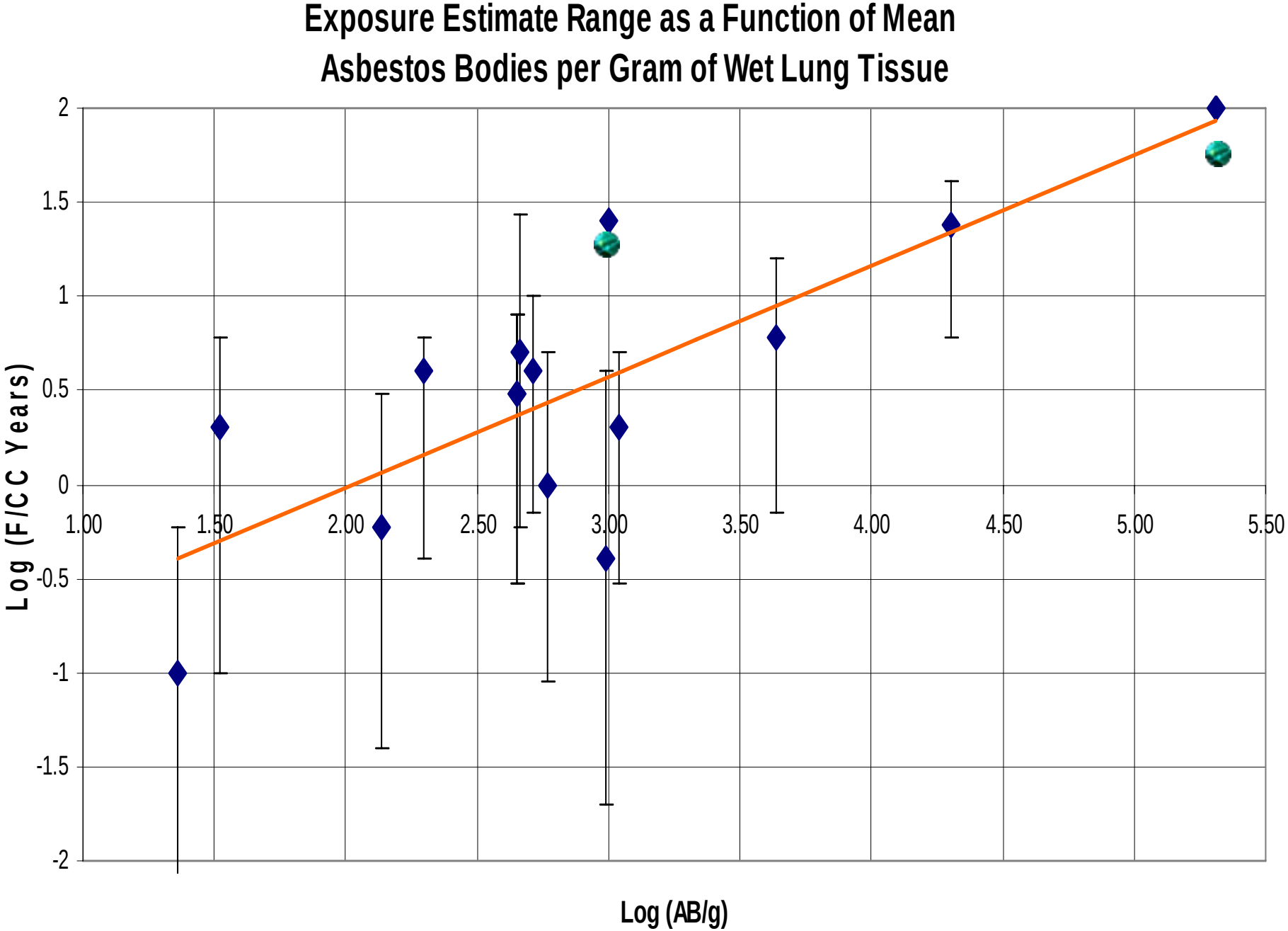
Further Information Gathering/ Re-Assessment

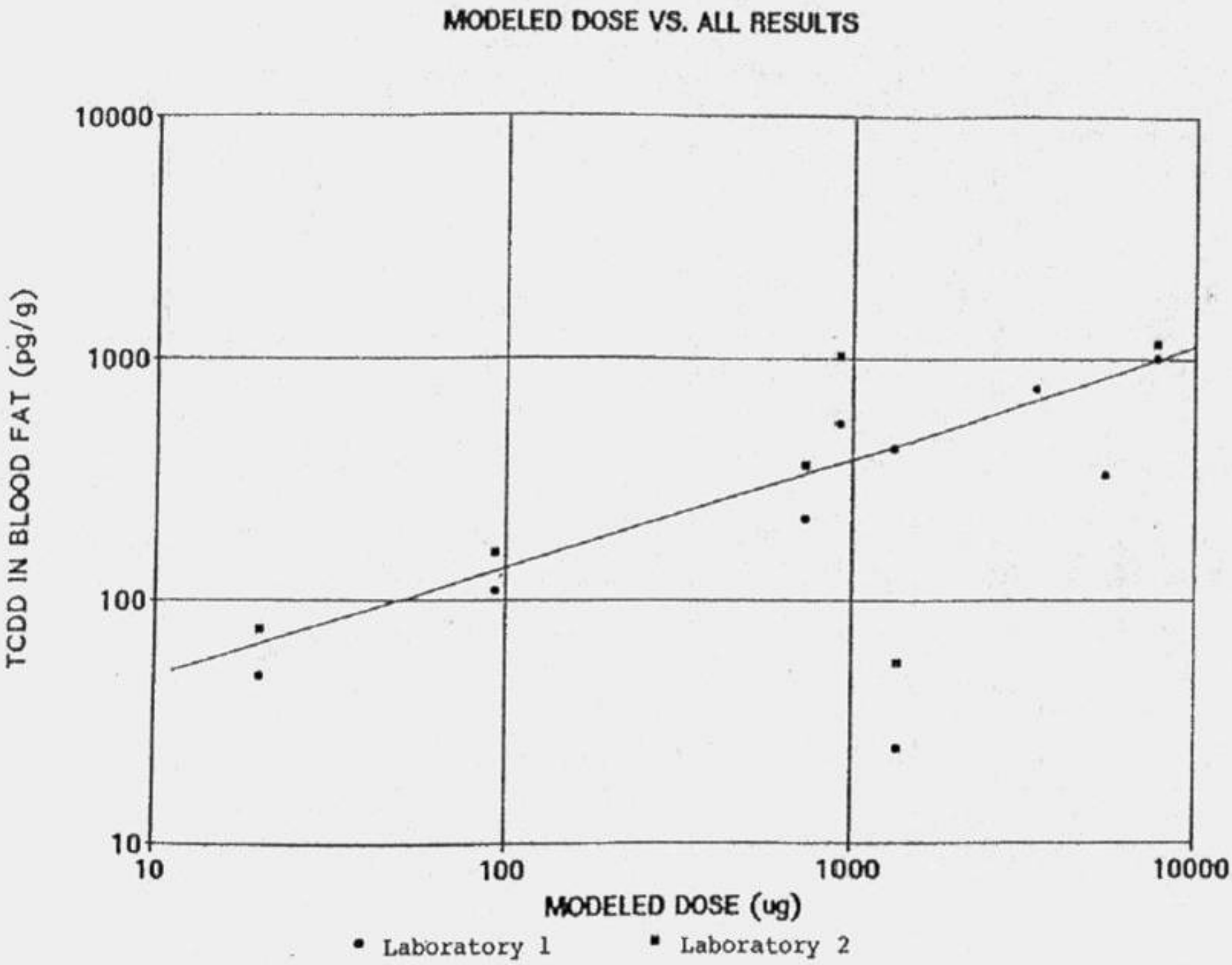
11. Validate assessment

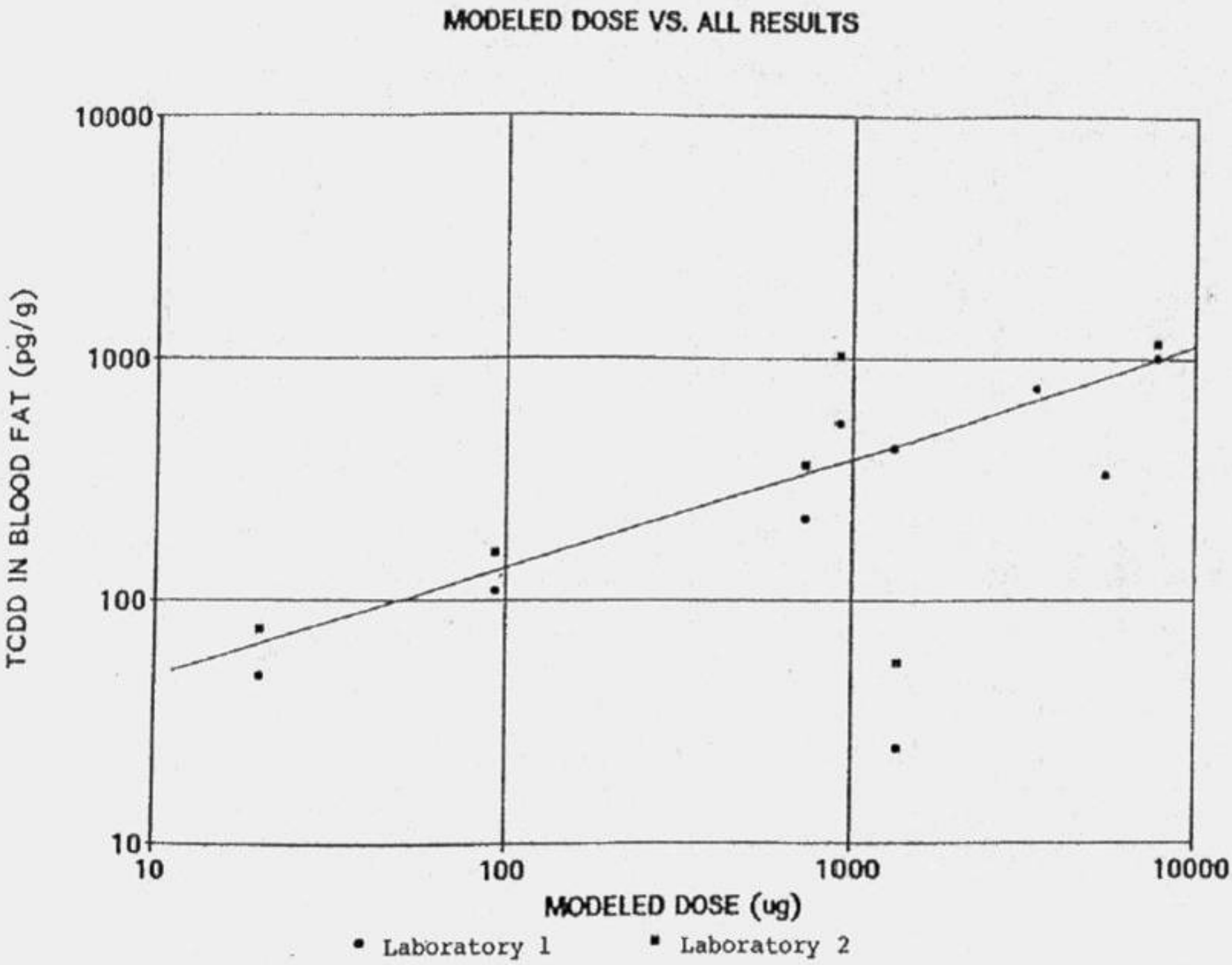
- Do results make sense?
- Compare subject biomarkers/ pathological or medical evaluation with results of REA
- Perform exposure re-creation studies
- Compare with alternate assessments performed by other individuals or groups
- Subject analysis to peer review/ listen to and adjust to criticism

Asbestos Bodies Per Gram of Wet Lung Tissue as a Function of Mid-Range Exposure Estimate




Exposure Estimate Range as a Function of Mean Asbestos Bodies per Gram of Wet Lung Tissue
Log (F/CC Years)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
Log (AB/g)


MODELED DOSE VS. ALL RESULTS
10000
1000
100
10
TCDD IN BLOOD FAT (pg/g)
10
100
1000
10000
MODELED DOSE (ug)
• Laboratory 1
▪ Laboratory 2


MODELED DOSE VS. ALL RESULTS
10000
1000
100
10
TCDD IN BLOOD FAT (pg/g)
10
100
1000
10000
MODELED DOSE (ug)
• Laboratory 1
▪ Laboratory 2

Further Information Gathering/ Re-Assessment

12. Report results

- Summarize results and their significance
  - Perhaps at beginning of report
- Craft a risk statement, if appropriate
- Use twelve-step program as an outline or checklist for content of body of report
- Document and reference all source material